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Preliminary

Effects of Curing on the Mechanical Properties of Japanese Lacquer Film*1

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Introduction

The Japanese lacquer, urushi, has been widely used for the coating of wooden products, and it is still evaluated as a useful natural lacquer for its excellent indoor durability and high resistance to water and chemicals. The Japanese lacquer is made from a sap of Japanese lacquer tree *(Rhus vernicifera)*, and its major constituent is urushiol, a mixture of catechol derivatives. When the Japanese lacquer ware is cured incompletely at a room temperature, it sometimes induces contact dermatitis due to the toxicity of urushiol unpolymerized. In order to prevent the trouble, heating is an easy and effective method to accelerate the polymerization of urushiol[1]. However, it should be considered that the pyrolysis of lacquer constituents may reduce the mechanical properties of coatings to degrade the practical performance of the lacquer ware. In this paper, the mechanical properties of the Japanese lacquer films cured at temperatures from 80 to 140°C are compared with those of the untreated ones, to discuss the practical effects of curing with heat.

Materials and Methods

The clear Japanese lacquer (suki-urushi, in Japanese) was applied on a Teflon plate and dried at 25°C and 95%RH for a few days. This process was repeated five times to make a 0.15 mm thick film. The film was then cut into strips of 70×5 mm, and some of them were cured at 80, 100, 120 or 140°C for 0.5, 1, 2 or 4 hours in an oven. These curing temperatures were lower than a temperature at which the remarkable pyrolysis occurs[2]. The tensile strength (σ_{max}) and strain at break (ε_{max}) of the strips were determined at 25°C and 60% RH. Six strips were tested for each curing condition. The effective span and the loading speed were 50 mm and 10 mm/min, respectively. After the tensile testing, the IR spectra of strips were measured by using the KBr method. Meanwhile, the appearance of films was observed before and after the immersion in water at 90°C for two hours.

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Results and Discussion

The σ_{max} and ε_{max} of the cured and uncured Japanese lacquer films are listed in Table 1. The changes in the mechanical properties were within the natural variation and experimental errors. In addition, the luster and deep black color of the film cured at 120 and 140°C remained almost unchanged by hot water immersion, while those of the uncured films were fairly degraded. These facts suggest that the curing will not induce serious troubles in the performance of lacquer ware, but improve the practical stability in its appearance. However, it should be noted that the curing affected the luster and color of the lacquer film to some extent. These slight changes may cause problem in the artistic quality of the lacquer ware.

The changes in the IR spectra due to the curing were analogous to those due to the prolonged aging at a room temperature. Although the aging generally results in the increase of σ_{max} and decrease of ε_{max}[3], the mechanical properties of lacquer film remained almost unchanged by

Table 1. Effects of curing on the tensile strength (σ_{max}) and strain at break (σ_{max}) of the Japanese lacquer film.

Temperature (°C)	Duration (hr)	σ_{max} (MPa)		σ_{max} (%)	
		Aferage	S.D.*	Average	S.D.*
Control		40.5	3.1	3.1	0.3
80	0.5	39.5	5.2	4.4	0.7
	1	41.4	4.2	3.6	0.7
	2	42.2	2.3	3.7	0.5
	4	41.5	4.4	3.5	0.7
100	0.5	38.7	5.0	3.3	0.6
	1	39.5	5.0	3.3	0.8
	2	39.5	5.5	3.3	0.8
	4	37.2	4.7	3.1	0.6
120	0.5	36.5	5.0	3.1	0.8
	1	38.6	4.5	3.8	1.1
	2	38.5	3.1	3.4	0.7
	4	39.3	4.8	3.3	0.7
140	0.5	38.7	5.2	3.3	0.7
	1	40.4	3.6	3.6	0.6
	2	40.8	2.8	3.5	0.5
	4	40.9	3.6	3.3	0.5

*: Standard deviation.

the curing. It was speculated that the effect of polymerization with heat was compensated with those of the pyrolysis, or that the structural changes due to the curing was something different from those due to the aging at a room temperature.

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